
Welcome to IKSEMICON
LED Lighting Seminar
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Contents

- ✓ LED 산업 동향
- ✓ Product Introduction
- ✓ Application guide

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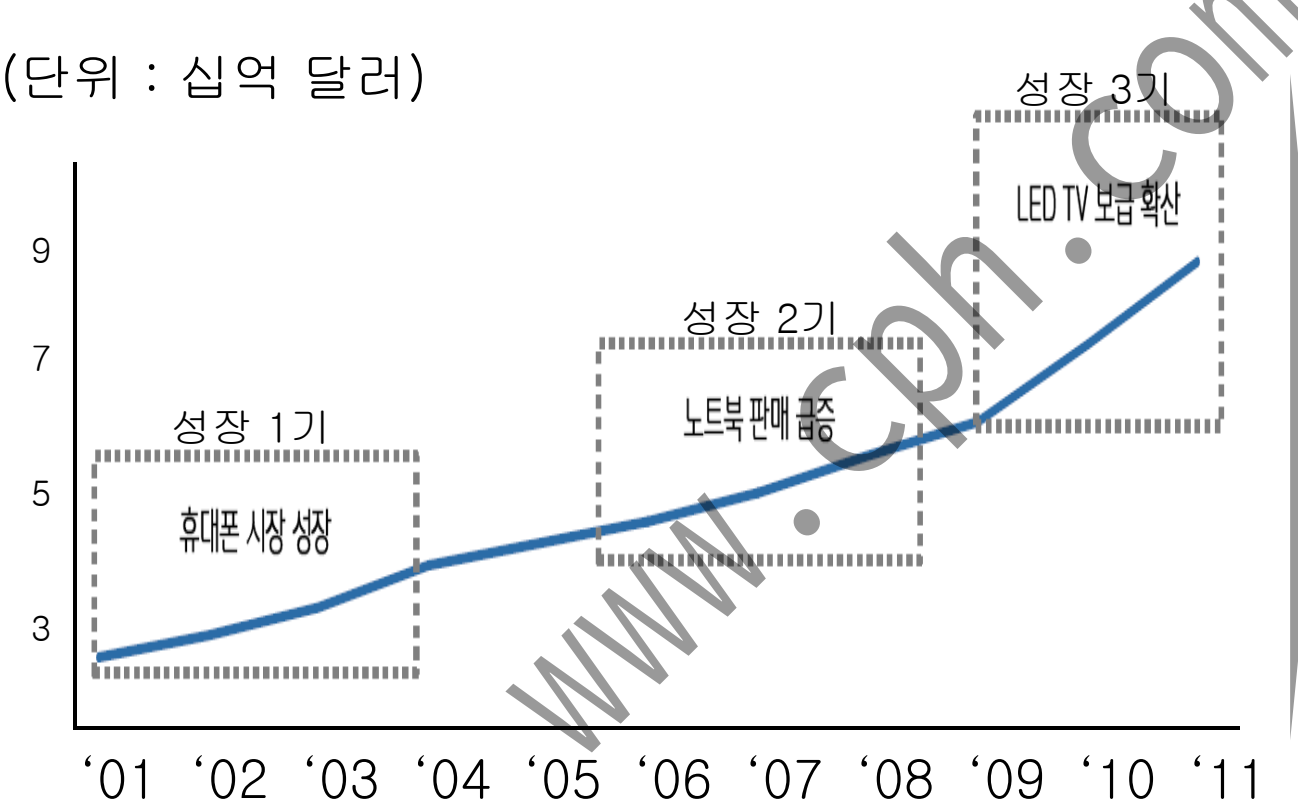
✓LED 산업 동향

➢ LED 산업 성장 History

LED산업은 휴대폰, 노트북, LED TV로 이어지는 성장 히스토리를 가지고 있으며, 2000년 20억 달러였던 LED시장이 2011년 90억 달러로 확대

LED산업의 성장



성장 1기(2000~2004년)
휴대폰에 LED 액정 보급 확대

성장 2기(2006~2008년)
저전력 및 슬림화 노트북에 LED 장착

성장 3기(2009~2011년)
LCD TV BLU로 LED가 사용되면서 본격적인 성장궤도에 진입

성장 4기 성장동력은 LED 조명

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➢ LED 산업 동향

2014년 백열전구 퇴출과 더불어 에너지 효율화 정책 및 LED 조명 가격 하락으로 급 상승 전망

기존 조명 vs LED 조명 비교

구분	기존조명	LED조명	비고
제어	On/Off	다색 및 다단계 밝기	지능 감성조명
응답속도	1~3초(형광등)	~10나노초	
광전환 효율	백열등 5%, 형광등 40%	최고 90% 잠재효율	고효율 광원, CO_2저감
수은	사용(기체광원)	무(고체광원)	친환경
발광대역	집중 불가	집중화	특수조명 활용
수명	3~7천 시간	5~10만 시간	유지관리 용이
내열성	우수	열에 취약	별도 방열설계
가격	저렴(형광등 약 3천원)	고가(1만~20만원)	보급애로

LED 조명으로 전환은 불가피

✓ 전 세계 조명기구의 연간 소비전력은 2조 1,000kWh, 전체 전력의 12~15% 소비
→ 전세계적 CO2 배출 규제 및 환경규제 강화 등으로 에너지 효율 향상, 유독물질 및 폐기물의 최소화가 요구되고 있고 이에 대한 해결책으로 LED 조명이 부상 중

✓ 2014년은 LED 조명 보급의 원년 : 백열전구 퇴출과 더불어 성장성이 더욱더 부각될 전망

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➢ LED 조명 응용 분야

■ 실내조명분야

- MR16조명 및 국부조명
- 전구 및 탁상조명
- 면발광 조명

■ 실외조명분야

- Wall washer 및 장식조명
- 정원등 및 보도등
- PV(Photovoltaic) 조명
- 가로등 및 다리조명
- 경기장조명 및 투광기

■ 특수조명분야

- 의료/농업/환경 조명
- 백색가전 조명
- 무대 및 연출 조명
- 엘리베이터 조명

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➢ LED Lighting 생산 Flow

1.LED wafer → 2. LED chip → 3. 단품 PKG → 4. Power PKG → 5. Module → 6. System → 7. Application

※ Key Factor

-. LED epi-wafer & Phosphor & 열 방열설계

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✓ Product Introduction

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➢ LED Lighting Products

Feature	IL9910	IL9961	IK2306	IK280x	IK402U
Function	Universal High Voltage LED Driver	Universal High Voltage LED Driver	MOS FET Switch LED Driver, 50mA	Constant current LED Driver	Linear LED Driver
Maximum supply DC Voltage	450V	450V	400V	30V	40V
Output Current	Up to >1A adjustable by external resistor	Up to >1A adjustable by external resistor	50mA, fixed	20 ~ 360mA per channel adjustable by external resistor	22 ~ 65mA adjustable by external resistor
Power Dissipation	630mW for SOP-8	630mW for SOP-8	740mW for TO-92 1600mW for SOT-89	800mW	Package type TBD
Thermal protection	No	No	No	Yes	Negative Thermal Coefficient
Short circuit protection	No	Yes	No	No	No
Dimming	ANALOG / PWM	ANALOG / PWM	No dimming	ANALOG / PWM	No dimming
Compatibility	HV9910	HV9961	HV9922	MBI1804	BCR402U

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➢ Universal High Voltage LED Driver – IL9910

The IL9910 is a PWM high-efficient LED driver specifically designed for driving multi-LED strings or arrays, supplied from voltage sources rating from $8V_{DC}$ up to $450V_{DC}$.
IC controls an external MOSFET at fixed switching frequency up to 300 kHz.
The operating frequency can be set using an external resistor.

FEATURES

- ► 8 V to 450 V input range
- ► LED string current can be set from a few mA to more than 1 A
- ► Brightness control for LED string from one to hundreds of diodes
- ► PWM low-frequency LED dimming
- ► Linear LED dimming
- ► Operating temperature range -40℃~+85℃

APPLICATION

- ► DC/DC or AC/DC LED Driver applications
- ► Low-cost off-line buck, boost or buck-boost converter control IC
- ► RGB Backlighting LED Driver
- ► Back Lighting of Flat Panel Displays
- ► General purpose constant current source
- ► Signage and Decorative LED Lighting
- ► Automotive / Chargers

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➢ LED Driver with Average-mode constant current control – IL9961

The IL9961 is an average current mode control LED driver IC operating in a constant off-time mode. this control IC does not produce a peak-to-average error, and therefore greatly improves accuracy, line and load regulation of the LED current without any need for loop compensation or high-side current sensing. The output LED current accuracy is ±3%.
The IC is equipped with a current limit comparator for hiccupmode output short circuit protection. The IL9961 can be powered from an 8.0~450V supply. A PWM dimming input is provided that accepts an external control TTL compatible signal. The output current can be programmed by an internal 275mV reference, or controlled externally through a 0~1.5V dimming input. IL9961 is pin-to-pin compatible with IL9910 and it can be used as a drop-in replacement for many applications to improve the LED current accuracy and regulation.

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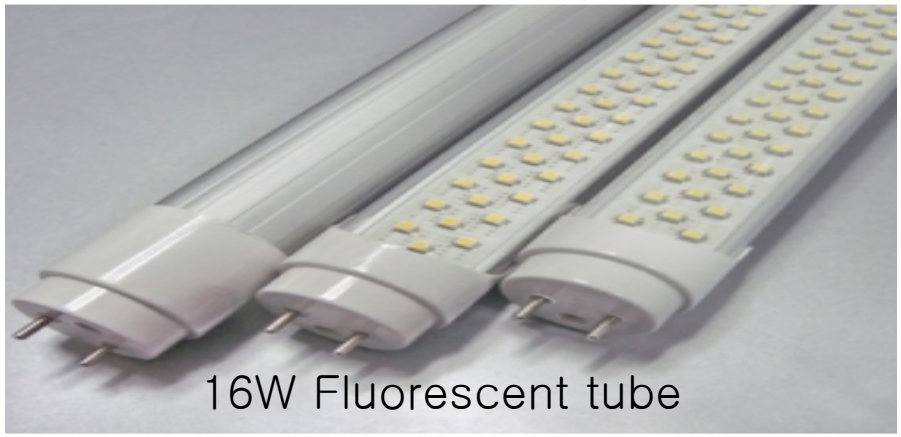
FEATURES

- Input Voltage range V_{IN} from 8 V to 450 V
- Control by Fast average current
- Programmed fixed duration of the current off state in the induction coil
- Linear LED dimming
- Option of LED brightness trimming by low frequency PWM signal
- Output short circuit protection
- IL9910 IC pin-to-pin compatibility
- Operating temperature range -40℃~+125℃

➢ Application



LED Tube Type

LED Bulb Type

LED Street lighting

LED Signage lighting

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➢ High voltage LED Driver with Build-in MOSFET Switch – IK2306

IK2306 is high-voltage LED driver control ICs with build-in MOSFET switch and purposed for LED lighting control. IC allows efficient operation of LED strings from voltage sources ranging up to 400 V_{DC}. The IK2306 include an internal high-voltage switching MOSFET controlled with fixed
off-time T_{OFF} of approximately 10μs. The LED string is driven at constant current, thus providing constant light output and enhanced reliability. The output current is internally fixed 50mA for IK2306. The peak current control scheme provides good regulation of the output current throughout the universal AC line voltage range of 85 to 264VAC or DC input voltage of 20 to 400V.

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FEATURES

- ON-resistance of the MOSFET switch 210 Ohm for ambient temperature 25 ºC
- OFF-state breakdown voltage of the MOSFET switch not less 500 V for ambient temperature 25 ºC
- Operating temperature range -40℃~+85℃
- Own Design item

➢ Application

Decorative Lighting

Low power Lighting

Architectural Lighting

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➢ High power Constant current LED Driver

IK280x is an instant On/Off LED driver for high power LED applications and exploits to enhance its output characteristics. At IK2802D/IK2804D/IK2816TSD output stage, (Two/Four/Sixteen) regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a large range of V_F variations.

IK2802D/IK2804D/IK2816TSD provides users (2-Ch/4-Ch/16-Ch) constant current ports. Users may adjust the output current from (40~360mA/40~240mA /5~60mA) through an external resistor, R_{ext}, which gives users flexibility in controlling the light intensity of LEDs. In addition, users can precisely adjust LED brightness from 0% to 100% via output enable with Pulse Width Modulation.

Additionally, to ensure the system reliability, IK2802D/IK2804D/IK2816TSD is built with TP (Thermal Protection) function and thermal pad. The TP function protects IC from over temperature (165°C). Also, the thermal pad enhances the power dissipation.

As a result, a large amount of current can be handled safely in one package

FEATURES

- ► Constant output current invariant to load voltage change
- ► Output current adjusted through an external resistor
- ► All Load Supply Voltage drift about 17V (Max)
- ► Schmitt trigger input
- ► 5V supply voltage
- ► Buit-in Thermal Protection
- ► Pin to Pin compatibility MBI1802/03/16 (Macroblock)

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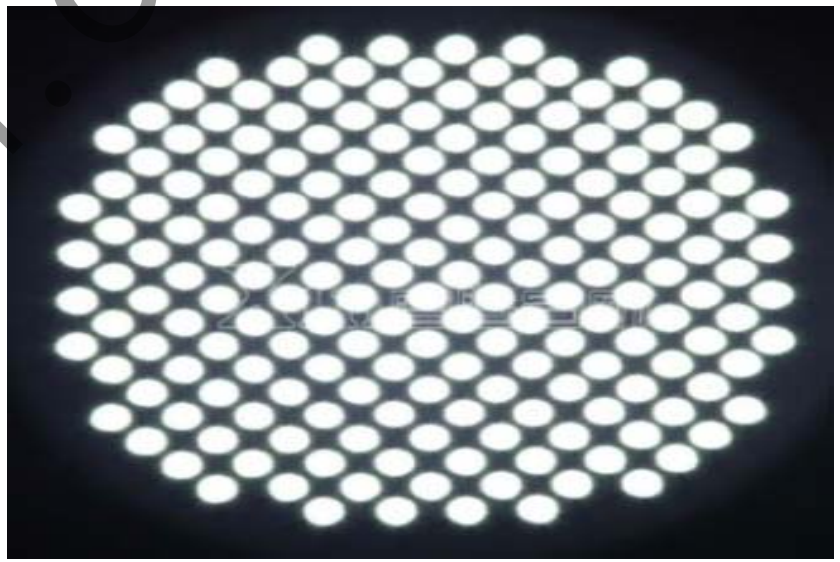
➢ Application

Characteristic		IK2802	IK2804	IK2816
Constant-Current Output Channels		2	4	16
Maximum output constant current per channel		360mA	240mA	60mA
Excellent output current accuracy	Between Channels (Max)	<±3%	<±3%	<±3%
	Between Ics (Max)	<±6%	<±6%	<±6%
Thermal protection		Yes	Yes	Yes
Package type		SOP-8	SOP-8	TSSOP-20

Channel letter lighting
IK2816



High Flux LED lighting
IK2802 / IK2804

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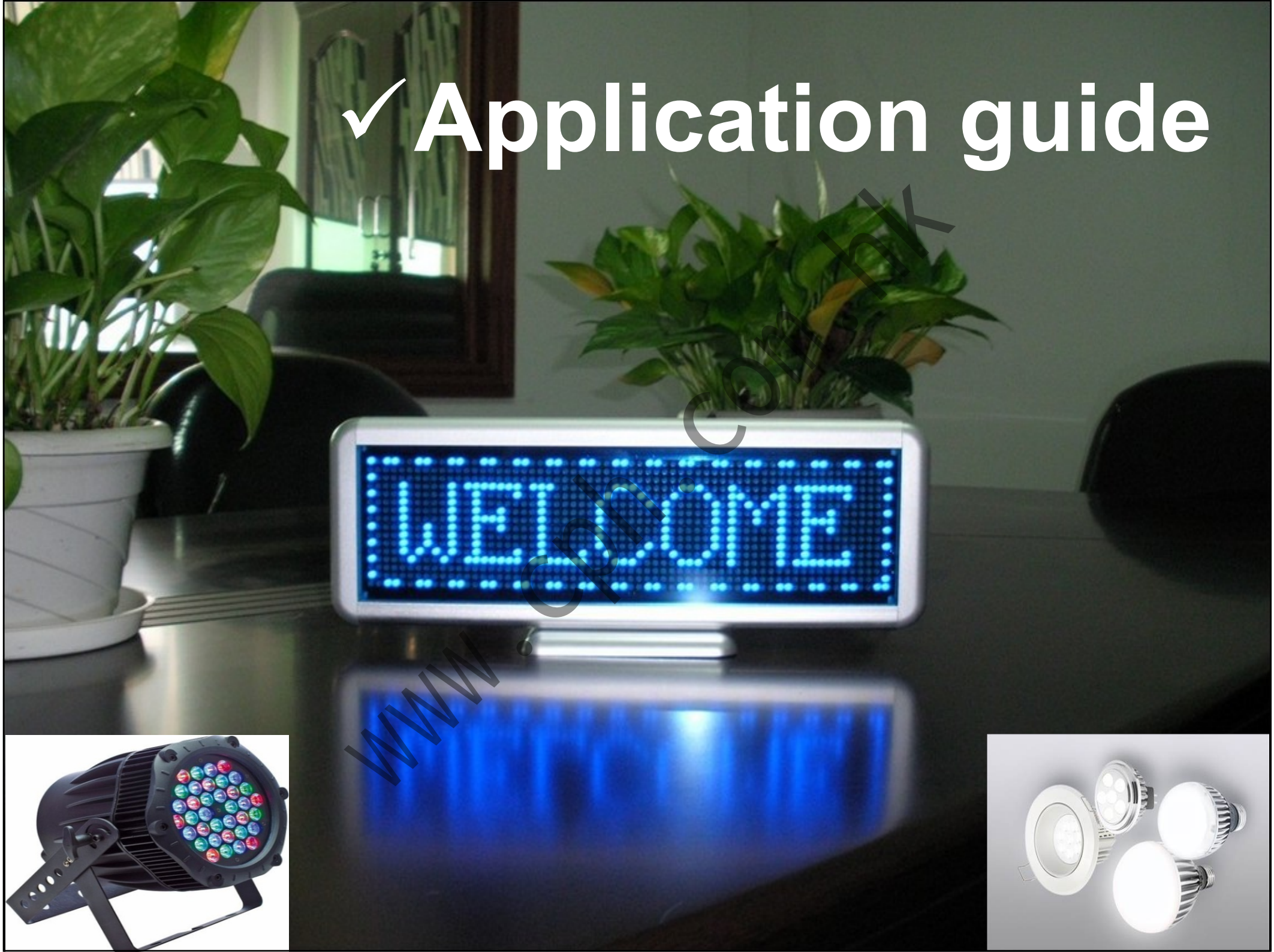
✓Application guide



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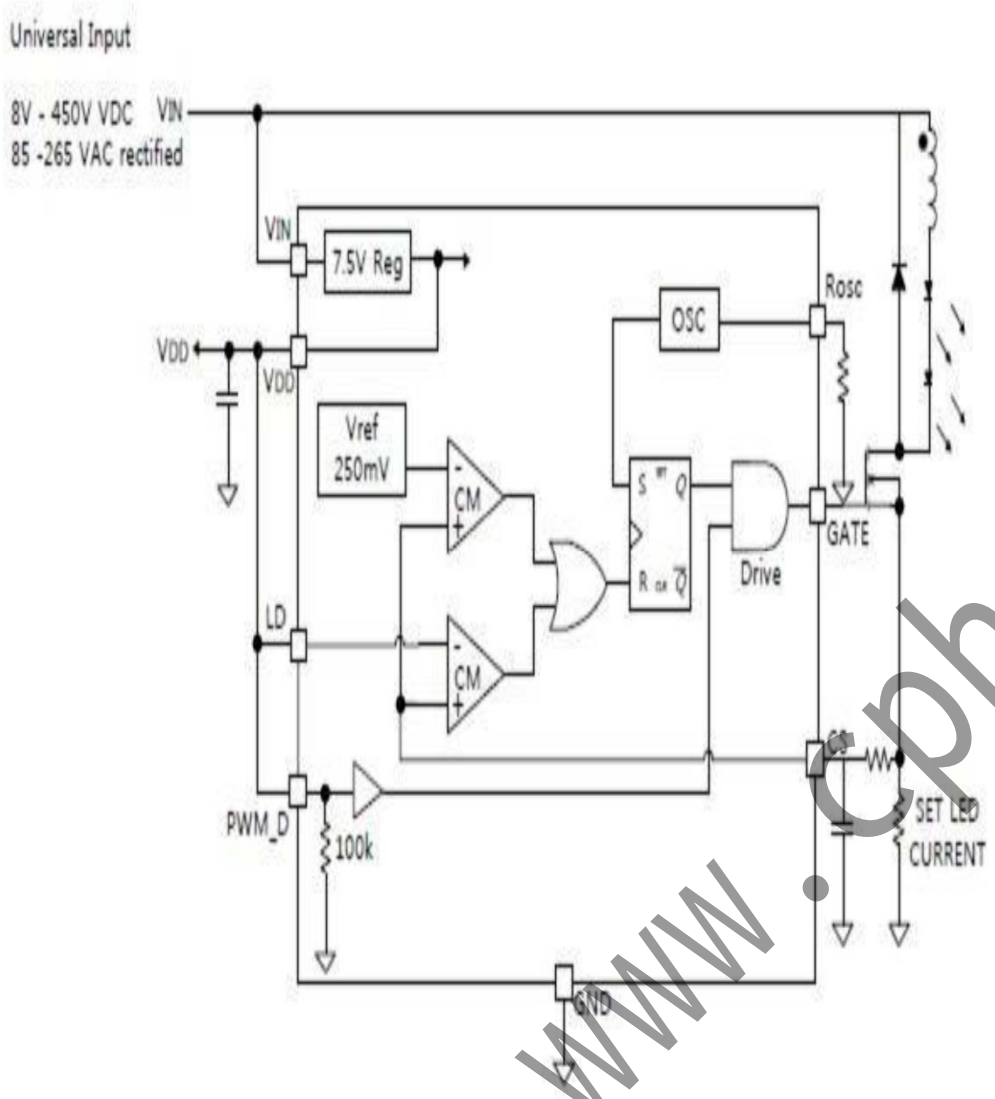
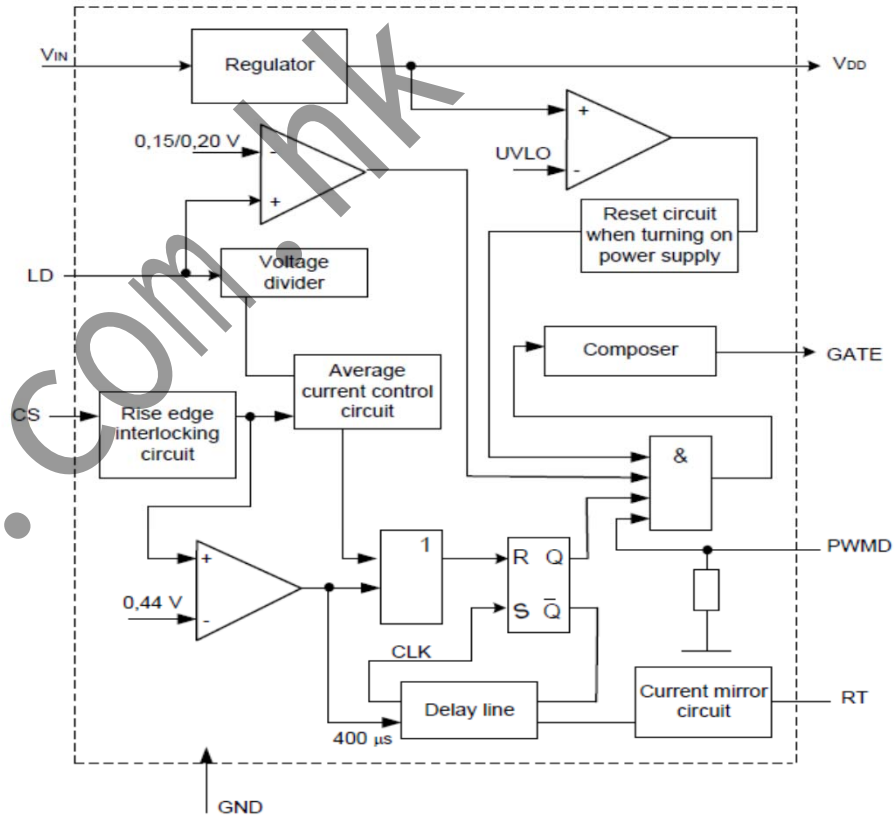
➢ Application guide – IL9910 / IL9961



[IL9910 Functional Block Diagram]



A1, A2, A4 amplifiers;
A3,A5logic elements
R1 trigger
T1 trigger

Figure 5 – IC Block Diagram

[IL9961 Functional Block Diagram]

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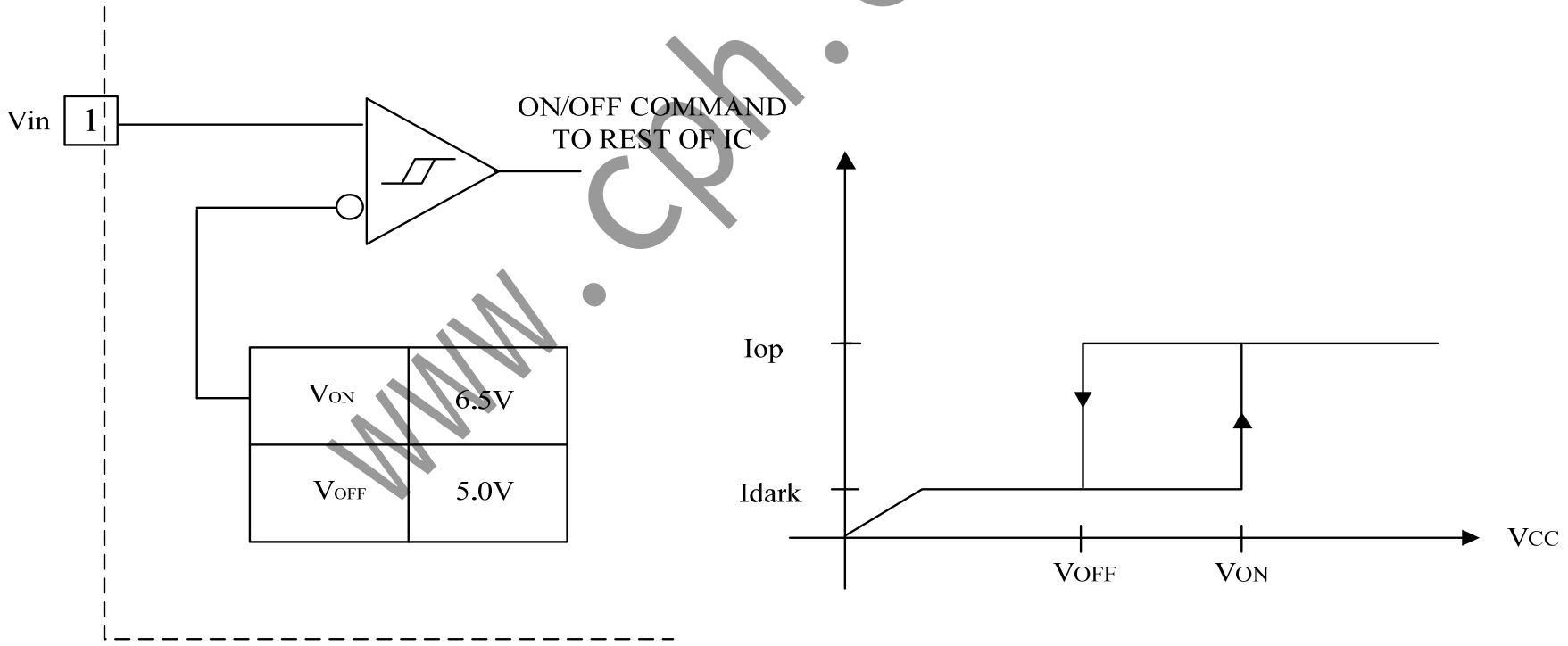
➢ IL9910 / IL9961 차이 점

▪ UVLO (Under voltage lock out)

Purpose: to provide more stable operation.

After turning on power, the UVLO function keeps the internal circuits in the standby state until the input voltage (VIN) reaches the UVLO VON threshold, it is to avoid malfunctioning of the product below the UVLO voltage. In case the input voltage (VIN) drops below the UVLO VOFF during operation, the UVLO function forces IC into the standby state to prevent to a malfunctioning.



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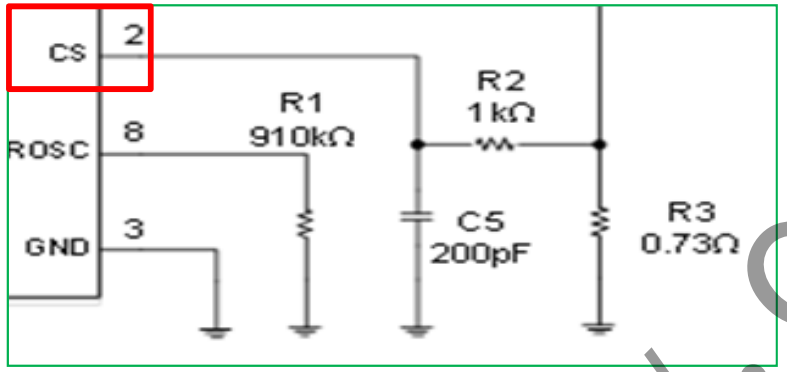
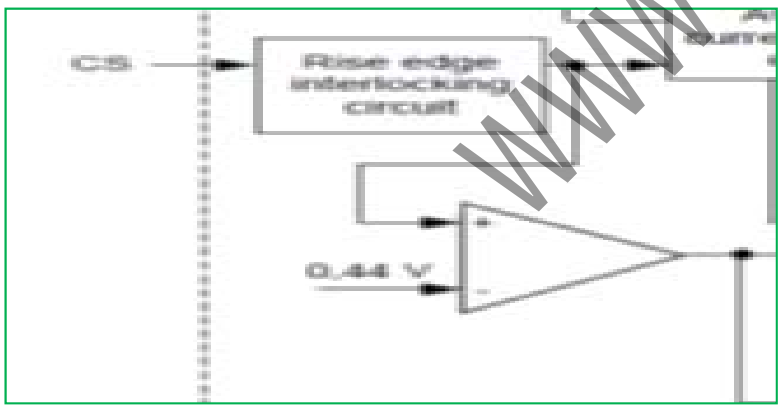
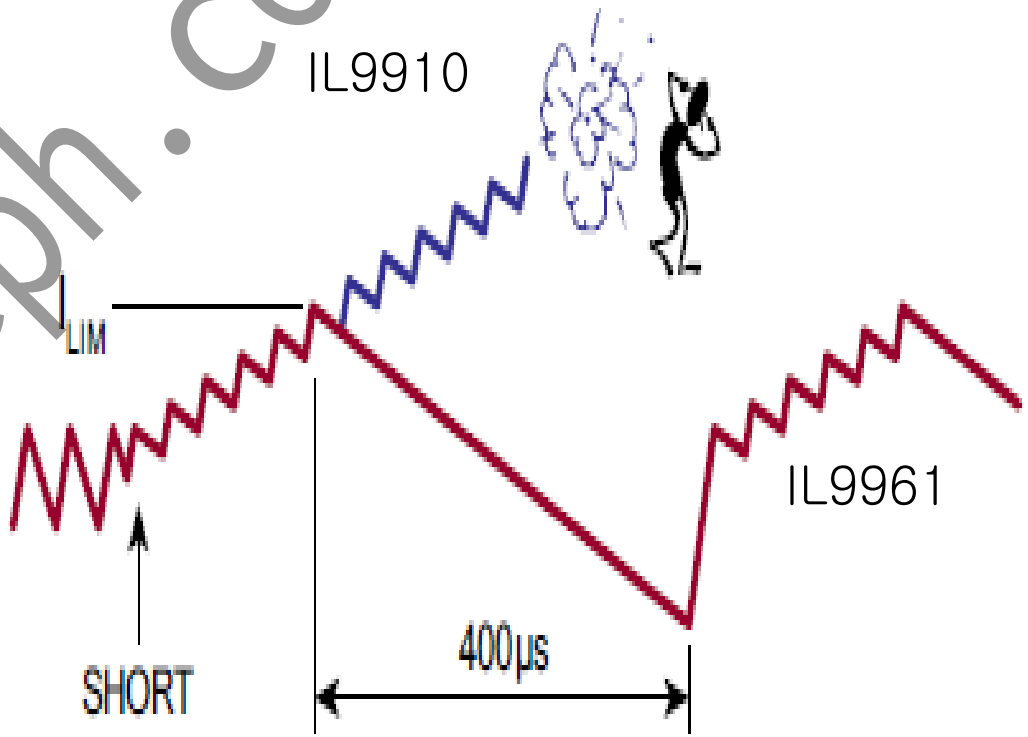
➢ IL9910 / IL9961 차이 점

▪ Short circuit protection

When a short circuit is applied at the output of the buck converter, the only voltage available to reset the magnetic flux in the inductor during tOFF is the rectifier diode voltage drop. When the converter keeps switching at the same frequency rate this may not be enough. Therefore, the inductor current will keep rising every switching cycle. The HV9961 is protecting the LED driver from such “staircase” saturation of the inductor by introducing a second threshold ILIM = 0.44V/RCS. When this threshold is reached, the GATE output becomes disabled for 400µs, thus letting the inductor current ramp down to a safe level.







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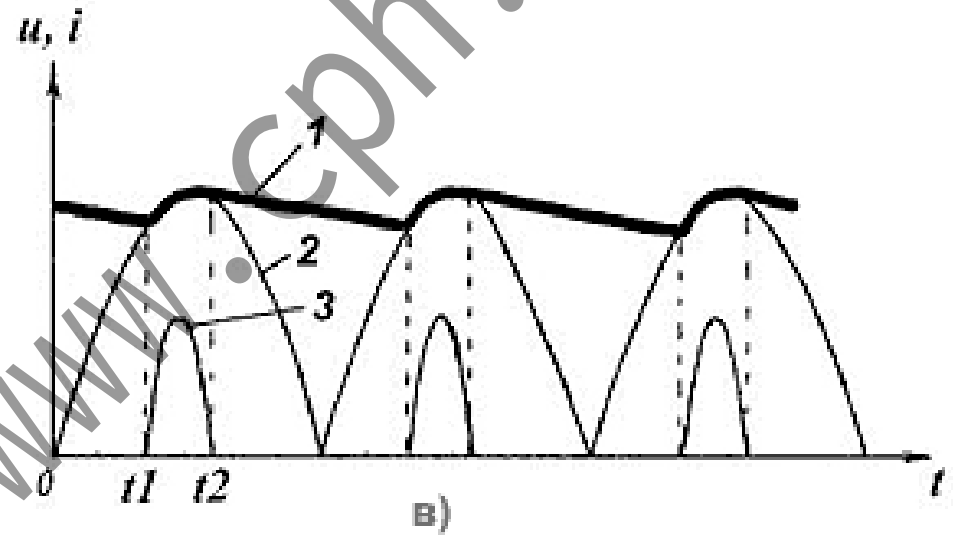
➢ Power factor and Total harmonic distortion

Low Frequency Mains Harmonics

The generation of harmonics is a consequence of the non linear behaviour of the load. The major contributor to this problem in electronic apparatus is the mains rectifier. The situation is often seen in off line switch mode power supplies but it is not a consequence of the switching process but rather the mains rectification. A typical off line switch mode power supply will contain a full bridge rectifier connected directly to the live and neutral lines and feeding a large smoothing / hold-up capacitor. It is this combination that is the source of the trouble.



1 – rectified Voltage, smoothed by capacitor
2 - rectified Voltage
3 – input Current

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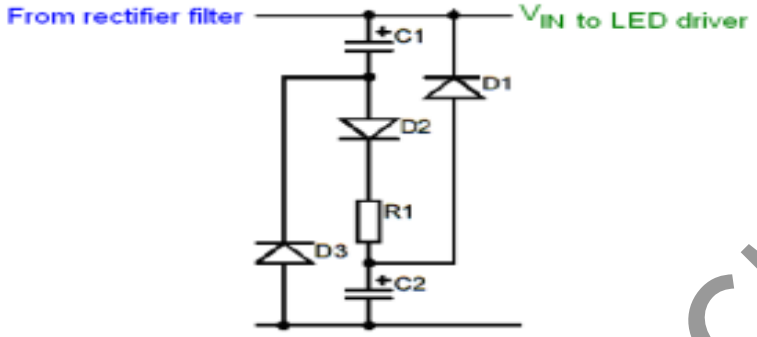
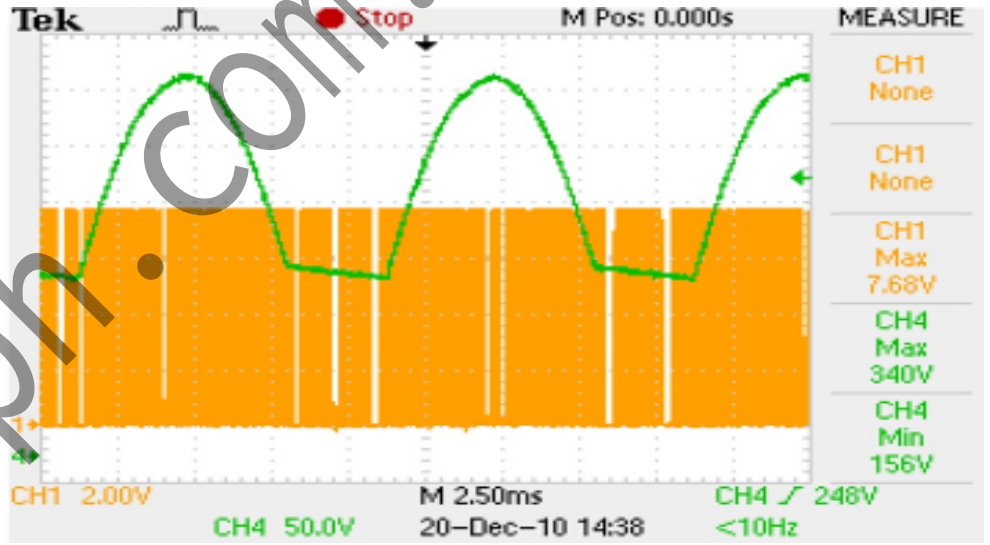
Passive Power Factor Corrector (PFC) – “Valley Fill”

The purpose of the valley fill circuit is to allow the buck converter to pull power directly off the AC line when the line voltage is greater than 50% of its peak voltage. During this time, capacitors within the valley fill circuit (C1 and C2) are in series and charged via D2 and R1. Once the line drops below 50% of its peak voltage, the two capacitors are essentially placed in parallel.

It allows to improve the line Current harmonic distortion and to achieve a power factor greater than 0.85





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➢ LED Dimming Function

- **LED** 는 수은이 없는 광원으로 진동 및 압력에 강하고 고속 응답성과 조도 **(Intensity of illumination)** 조절 **(Dimming)** 이 강점.

-. Analog Method : **IL9910 / IL9961**

-. PWM (Pulse Width Modulation) : 추가적인 **Circuit** 필요

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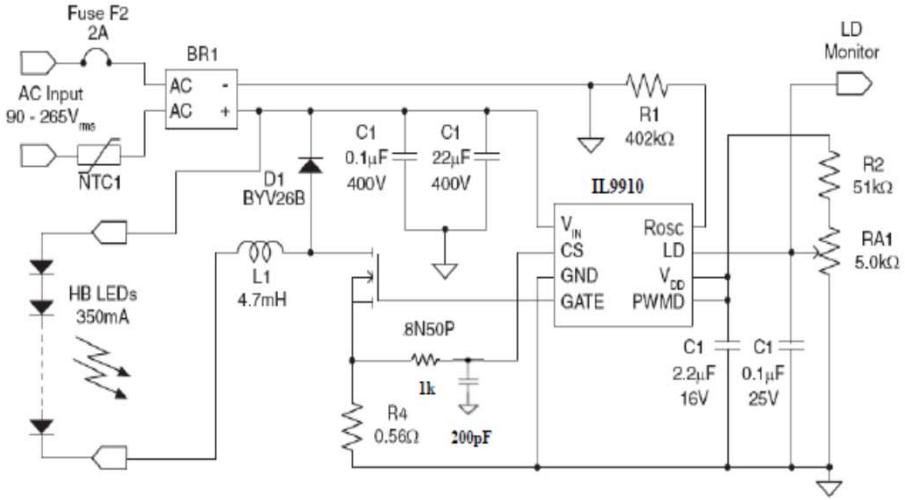
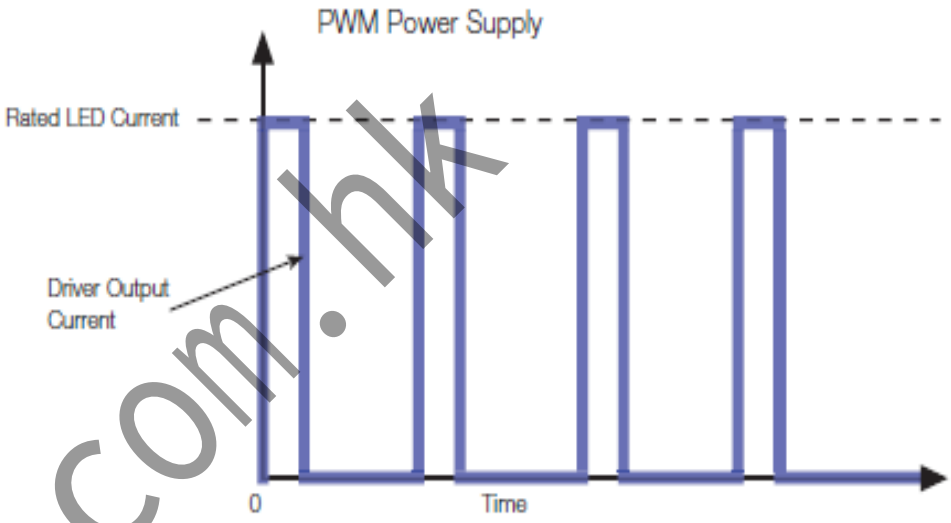
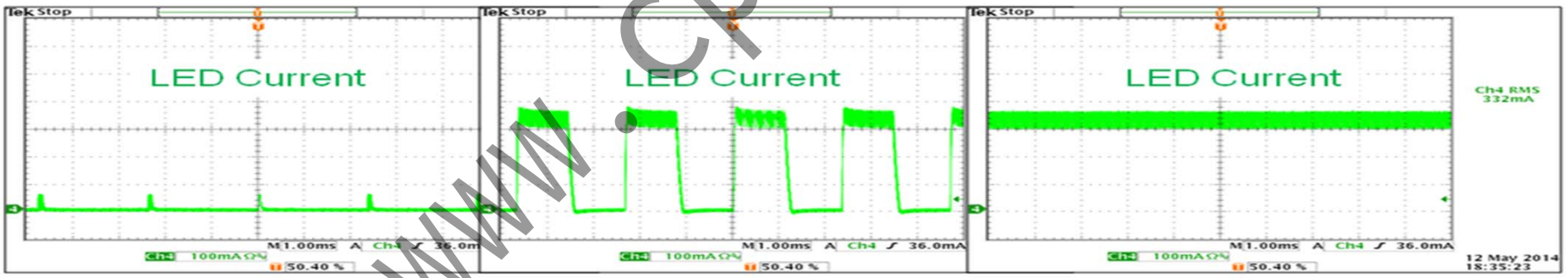
➢ Dimming Function



Typical Linear Dimming Application Circuit



PWM Dimming performance:



Minimum Middle Maximum

*PWM Dimming Range is 0.1~100%
*Current consumption: 0.7mA
*Frequency is constant in the whole Duty Range.
*Frequency can be adjusted by R1 and C1 values.

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➢ IL9910 / 9961 Demo board outline

✓ Specification of the Demo board

. Input Voltage : AC 230V
. Oscillation Frequency : 28kHz
. Output Current : 350mA
. Output Voltage : 9V

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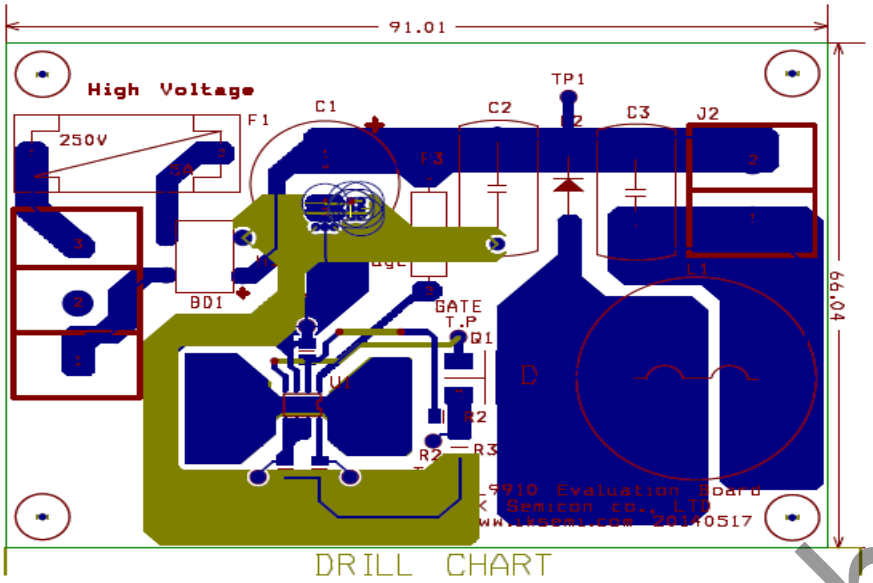
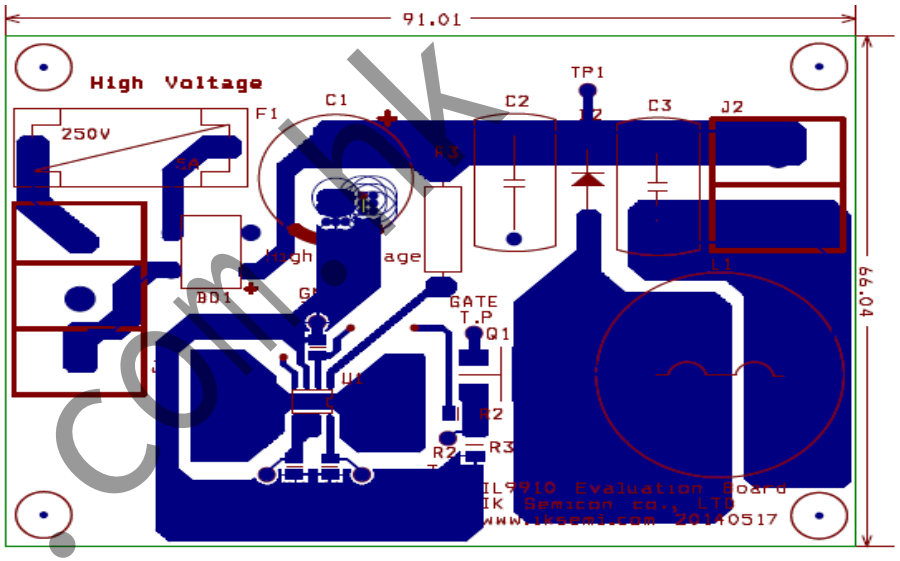
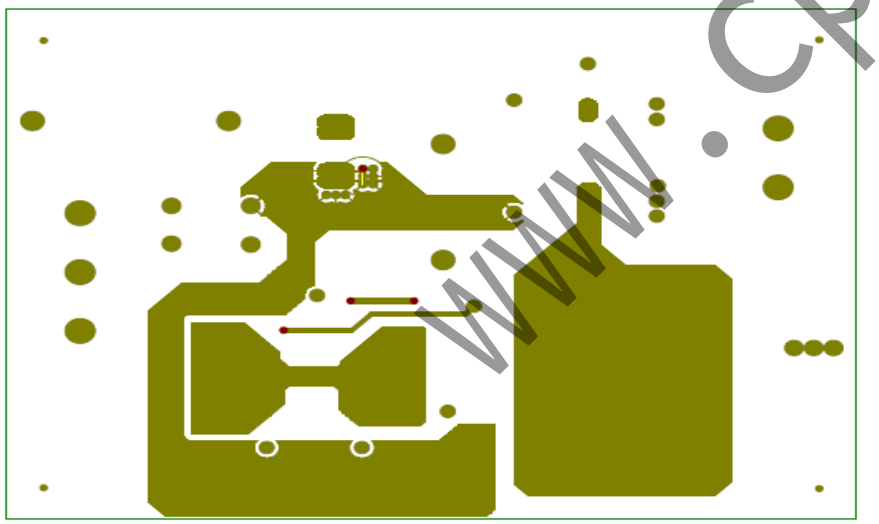
➢ IL9910 / IL9961 Demo board Gerber (제조:MISSIONTECH)



Total Layer



TOP View



Bottom View

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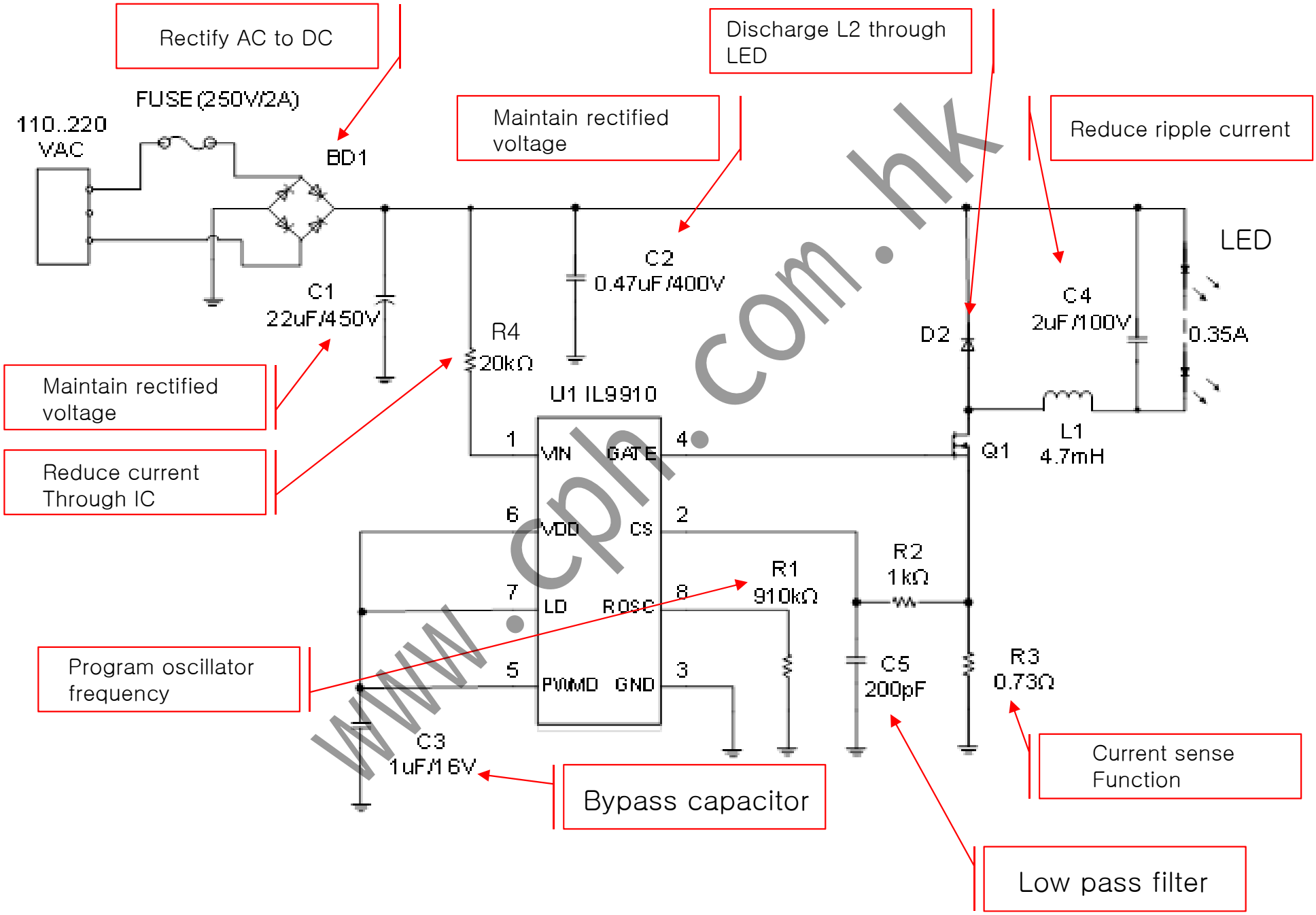
➢ IL9910 / IL9961 Demo board circuit



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➢ IL9910 / IL9961 Demo board 설정

✓ Calculation

Set f=50kHz

T=1/f=1/50=20us

Duty=Vout/Vin=80/(220*1.4)=0.26

ton=D*T=0.26*20=5.2us

toff=T-ton=20-5.2=14.8us

Rcs=0.25V/(1.15*Io(A))=0.25/(1.15*0.35)=0.62Ω

Rt=tosc*25kΩ-22kΩ=20us*25kΩ-22=478kΩ

Lo=Vo*toff/(0.3*Io)=80*14.8/(0.3*0.35)=11mH

Limitations

Vo<0.5*Vin, for Vin=220VAC or 310VDC Vomax=310/2=155VDC

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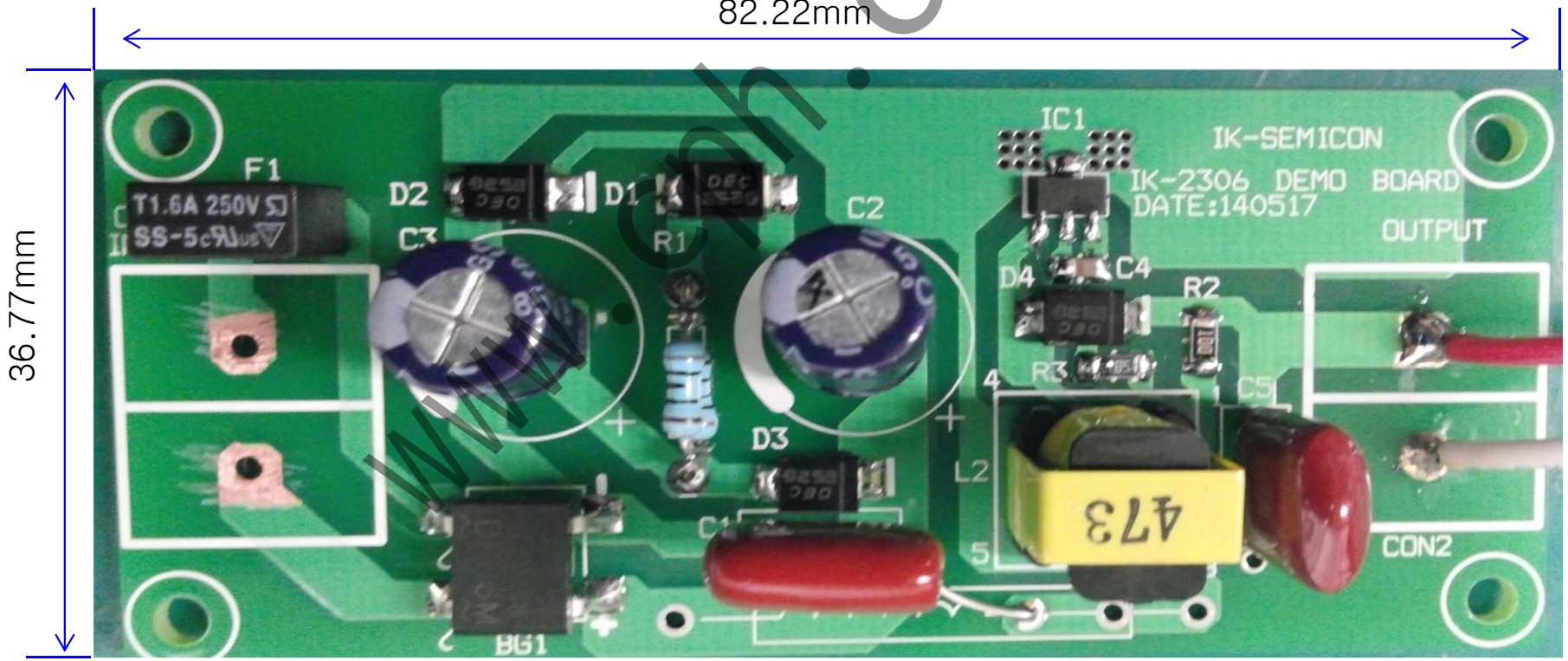
➢ IK2306 Demo board outline

✓ Specification of the Demo board

. Input Voltage	: AC 220V
. Output Current	: 40mA
. Output Voltage	: 125DCV
. PFC	: ≥ 0.9
. THD	: ≤ 40%



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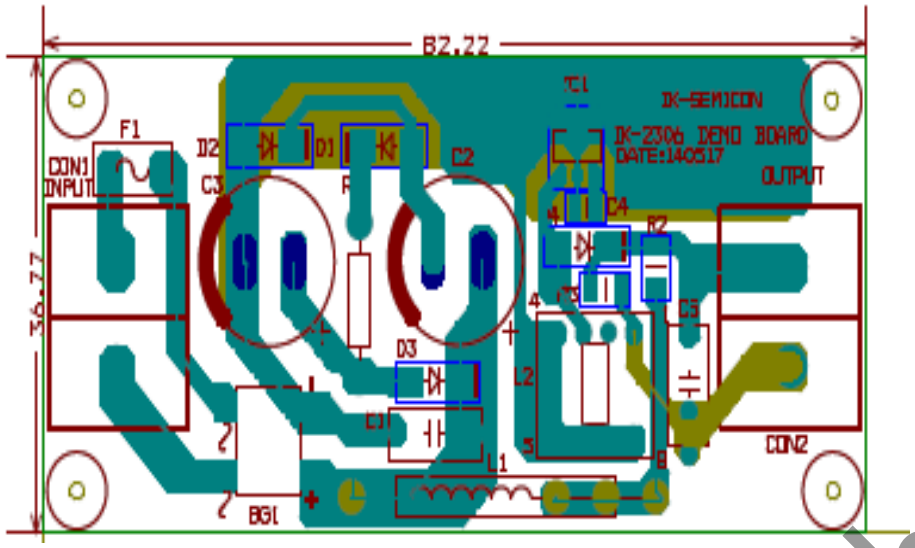
➢ IK2306 Demo board Gerber (제조: MISSIONTECH)



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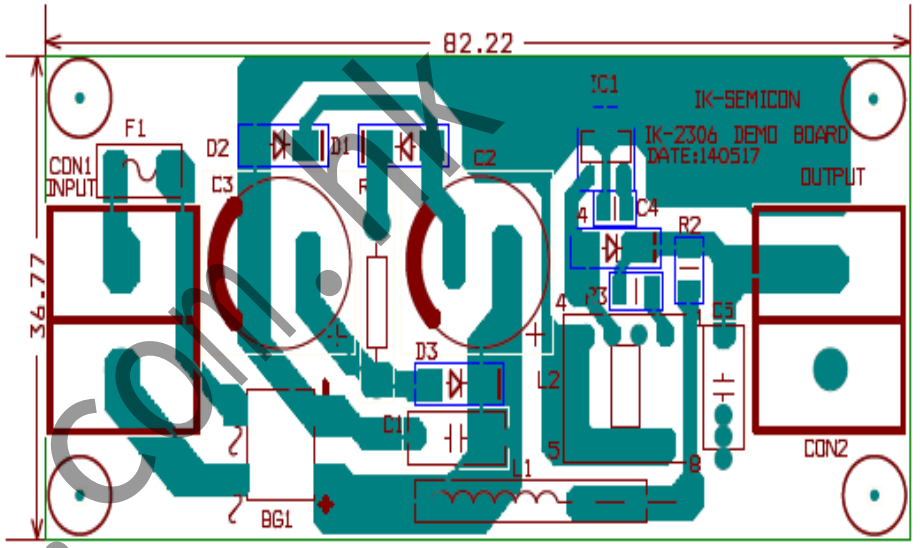
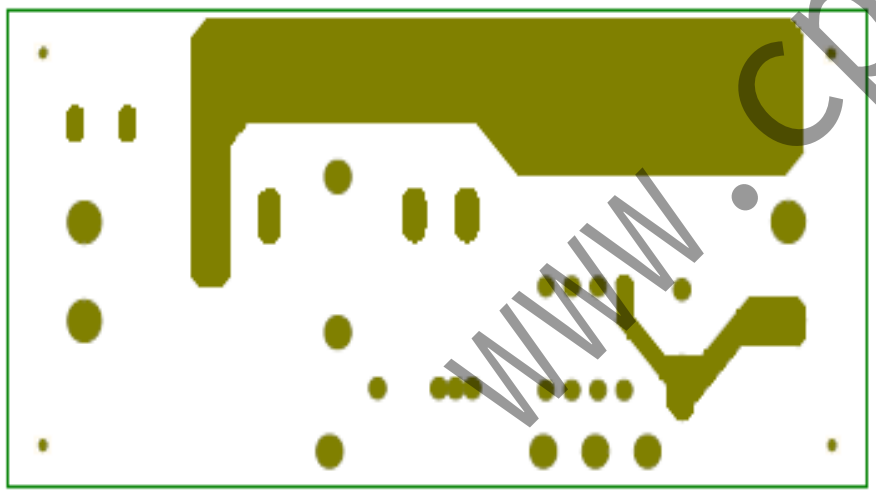


TOP View



Bottom View

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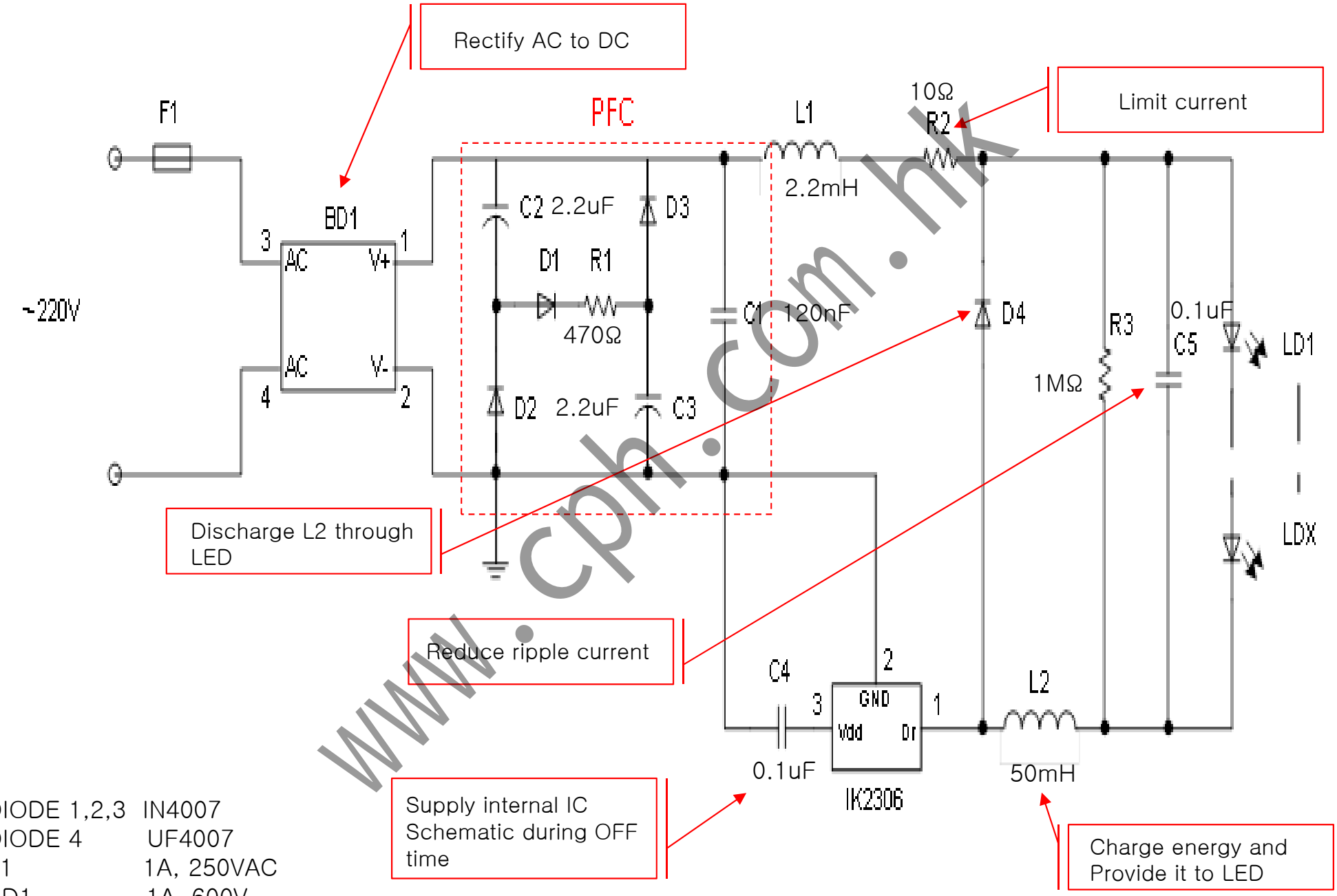
➢ IK2306 Demo board circuit



- DIODE 1,2,3 IN4007
- DIODE 4 UF4007
- F1 1A, 250VAC
- BD1 1A, 600V

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➢ IK2306 Demo board 설정

✓ Calculation

Lo=Vo*toff/(0.3*Io)=150V*10.5us/(0.3*50mA)=105mH
Select L1 19R107C, L=100mH, I=70mA. Typical SRF=170KHz.

Calculate the coil capacitance.
Cl=1/(Lo*(2*3.14*SRF)^2=1/(100mH*2*3.14*170kHz)^2=8.8*10^{-12}=9pF

Total capacitance:
Cp=Cdrain+Cpcb+Cl+Cdiode=5pF+5pF+9pF+8pF=27pF

Calculating the leading edge spike duration
Tspike=Vin*1.4*Cp/Isat+Trr=264*1.4*27pF/150mA=66ns<Tblank_min (200ns)

Power dissipation:
Fs=(Vin-Vo/η)/(Vin*Toff)=(373-150/0.7)/(373*10.5us)=40kHz
Pswich=(Vin^2*Cp/2+Vin*Isat*Trr)*Fs=(264^2*27pF/2+264*0.15*20ns)*40000=69mW

Minimum Duty ratio:
Dmin=Vo/(0.7*Vin)=150/(0.7*264*1.41)=0.57

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➢ IK2306 Demo board 설정

✓ Calculation

Conduction power loss:

Pcond=Io^2*Ron*Vo/Vin+Idd*(Vin-Vo)=0.05A^2*210*150/373+350uA*(373-150)=289mW

Total power loss:

Ptot=Pswich+Pcond=69mW+289mW=358mW

Selecting Input Capacitor Cin:

Pout=150V*50mA=7.5W

Cin=0.1uF/W=0.1*7.5=0.75uF, select 1uF, 400V

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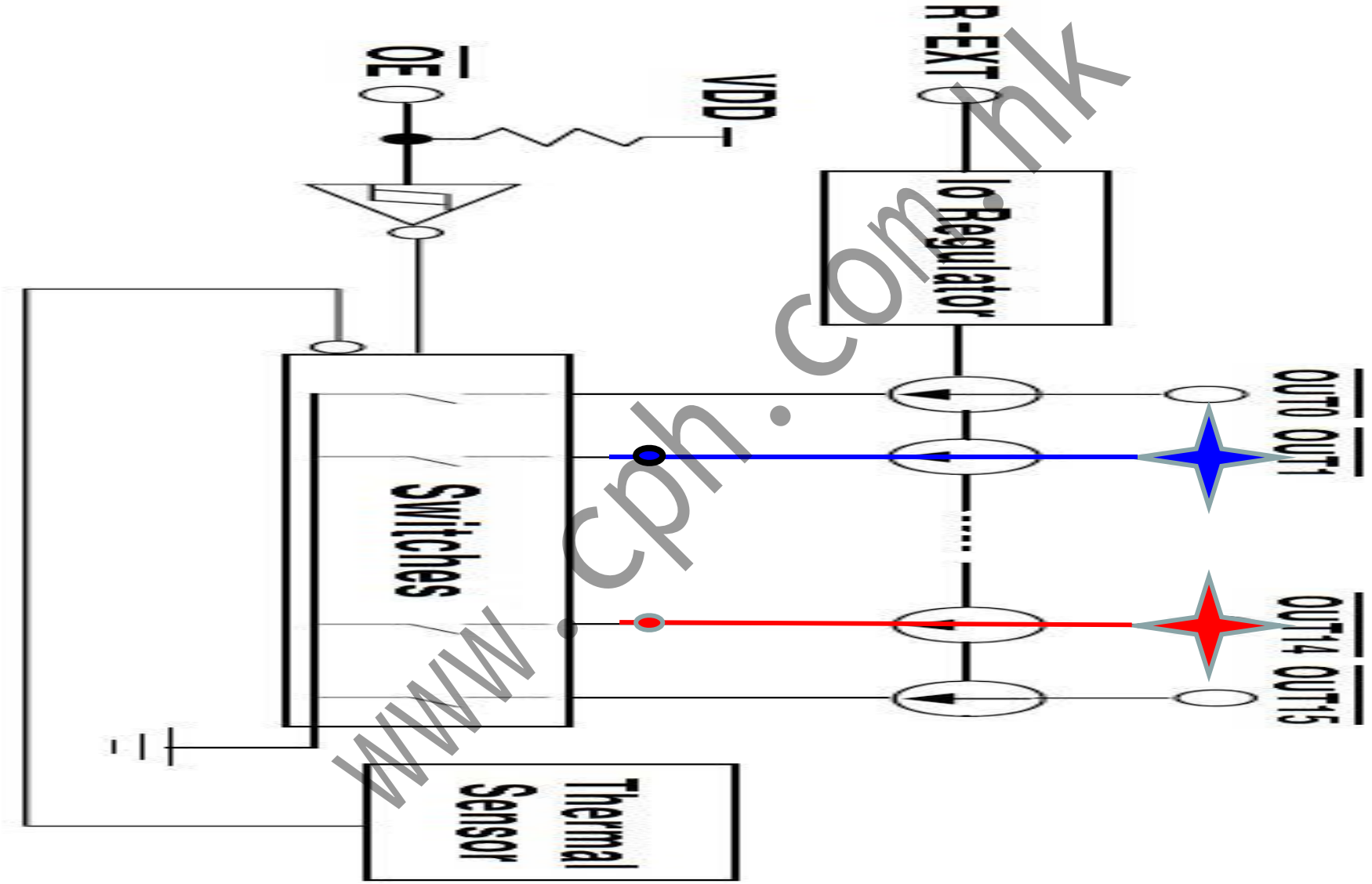
➢ IK280x Application guide



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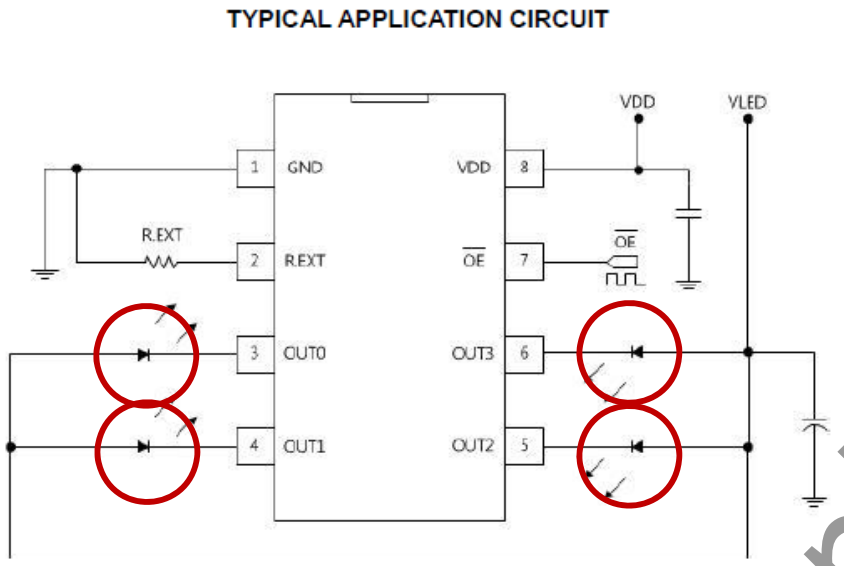
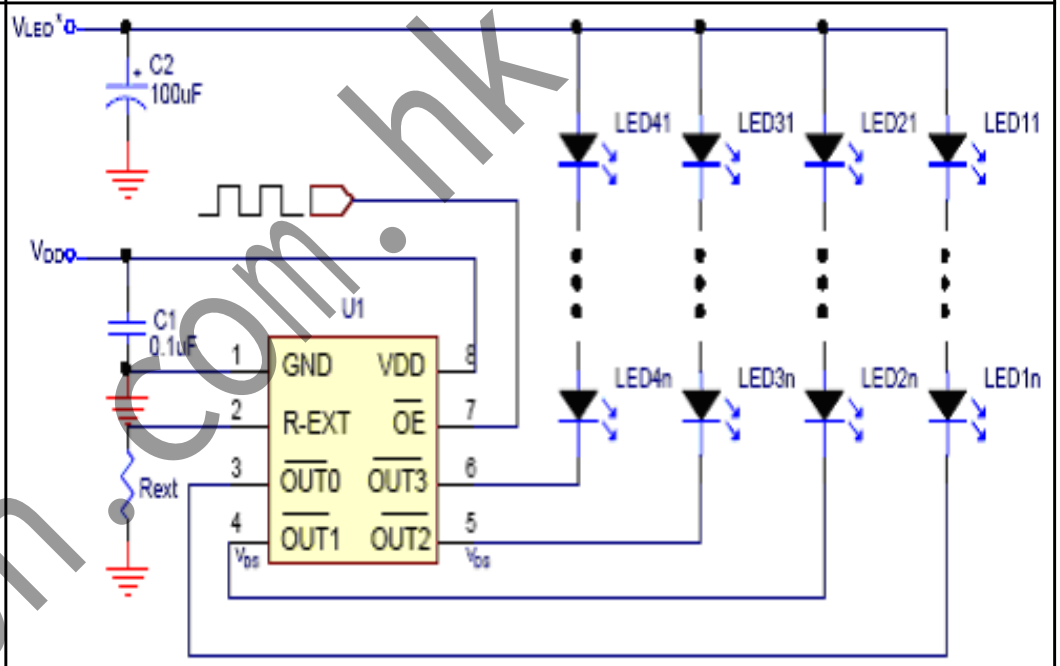
➢ IK280x Application guide

Typical Application Circuit	Application Circuit
	
1. 각 Output 단자 최대 240mA 전류 출력가능 (개별분리) ** MacroBlock MBI1804 (18V Process) ⇔ IK Semicon IK2804D (36V Process) ESD 부분 강점 (LG 냉장고 Set (내등 Application에 적용)	1. 현재 Out Port (OUT0~4 : 출력 개별 분리 필요) ⇒ 출력 Port의 전류편차 간섭 인해 각 Port 정 전류 출력 안되고 PIN 2 (Feedback)의 문제로 LED 출력 Flicker 현상 **2. 출력전류 관련 240mA 이상으로 필요하면** **1) Out Port (PIN 3, 4, 5, 6) 마다 개별 LED 배열 (240mA) 구성** **2) Out Port (PIN 3, 4, 5, 6)에 각 저항 (3216 Size) (10~22Ω)를 추가 구성**

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